are, where we now find them, distillates. In making this declaration I do not wish to be understood as calling in question the correctness of either the observations or opinions of those who have reached different conclusions.

Perhaps fifty years from now our ghosts may sit here with our grandchildren and hear them dogmatize concerning the origin of bitumen. For myself, the longer I study the subject and the wider my experience becomes, the less I am prepared to assert that any formula is capable of universal application. I would therefore suggest, that, as we now find them, bitumens are in some instances still where they were originally produced by a process of decomposition of animal remains, that is at present being illustrated on a small scale in the shallow bays of the Red Sea. Further, that other deposits contain primary distillates from the vegetable and animal remains enclosed in geological formations that have been invaded by heat, steam and pressure in past periods of the earth's history; and finally, that in some instances, as we now know them, bitumens have been transferred and stored by a secondary invasion of bituminous deposits by heat, steam and pressure. The details of these various movements await for their expression a vast amount of chemical and geological research by those who are to come after us.

A SUGGESTION AS TO THE ORIGIN OF PENNSYLVANIA PETROLEUM.

BY DAVID T. DAY.

(*Read February 5, 1897.*)

The three general classes of theories as to the origin of petroleum are so well known as to call for no especial description. I refer to (1) the inorganic origin by the action of water on metallic carbides; (2) by the slow decomposition of vegetable remains with insufficient supply of air, with or without simultaneous production of coal; and (3) the distillation of the fatty portion of anima organisms under pressure, in accordance with the discoveries generally credited to Engler.

It is pleasant, however, to recall attention to the fact, which has frequently been lost sight of, that Warren and Storer first distilled petroleum from animal fats years before; that is by the distillation

of menhaden oil soaps under pressure they made good kerosene and actually sold the product—an achievement remarkable for the time at which it was done and gratifying to us as the work of American investigators and far in advance of any similar work abroad. The work of the German chemist, Engler, is thus simply confirmatory, and in extension, of what had been already done in this country.

Concerning these theories of origin, it seems to me extremely probable that the conditions required for the production of bitumens by inorganic means must have occurred repeatedly in the earth's crust, and that, therefore, bitumens have been formed by such means. The evidence of the actual occurrence of bitumens produced from inorganic sources is not complete, but in addition to the bitumens occurring in trap rock in eastern New York and Connecticut, it is well to call attention to the fact that water associated with the Trinidad asphaltum has been shown by Mr. Clifford Richardson to contain significant amounts of boracic acid compounds, which is some evidence of volcanic origin. Again, bitumens occur in the vein quartz of quicksilver deposits in various parts of the world, and such occurrences are frequent in California.

If we take into consideration the organic life available for yielding petroleum, it seems easier to believe that the supply of oils found in the Silurian limestones has come from the distillation of fats associated with *animal* remains, than that they were derived from *vegetable* matter.

On the other hand, general opinion tends to associate the Pennsylvania oils with a vegetable source, and it is against this that I wish to make a few suggestions, based upon the observations of Rev. John N. MacGonigle, formerly a stratigrapher in the employ of the Forest Oil Co. Mr. MacGonigle's opinion is that the Pennsylvania oils were originally contained in the Silurian measures, as are the Ohio oils, and that a redistillation, accompanied by a transfer to rocks of the Devonian age, resulted in a change of the character of the oils.

In his own words, as written to me, Mr. MacGonigle states:

"It may be admitted that the marvelous deposits found in the Trenton and Clinton limestones and widely diffused in the other limestones and shales of the Silurian period are indigenous. It is a well-known fact that the series constituting the Silurian age, as the result of one of nature's wonderful convulsions, sweeps toward the eastward under the Devonian and Carboniferous areas, forming

the floor of the basin in which the measures of these periods were deposited. The uplift which forms the Appalachian chain occurred at the close of the Carboniferous period. This was due directly to heat action. It is, therefore, at least suggested that the petroleums of Pennsylvania owe their origin to the effect of this heat upon the underlying limestones and shales of the Silurian age. The theory is, that the same force which caused the Appalachian chain to uplift, passing through the limestones and shales of the Silurian age at a modified temperature, distilled the oil already contained in these shales and conglomerate sands of the Devonian age, where it was condensed and filtered and found its home in the open, porous conglomerates which characterize the Catskill, Portage and Chemung periods of the Devonian age.

"There are many reasons why this theory seems to be more satisfactory, to me, than any of the others. In the first place, the peculiar characteristic of the Silurian oil is its well-known sulphur compound, which for many years presented almost insurmountable difficulty to the refiner. The low specific gravity is its second characteristic quality, and a uniform quality marks it everywhere. In the oils of the Pennsylvania region and the Devonian horizon we have a range of color from light amber to black, a higher specific gravity and almost entire freedom from sulphur compounds.

"In addition to what has been said with reference to the Silurian period, it may also be added that at its top lies the Corniferous limestone, which is the source of the petroleum of western Canada. This limestone has been reached by the drill in Pennsylvania in the well at Erie and at the Conway well, which, piercing the Venango-Butler group, reaches the Corniferous limestone. In neither case was any trace of oil discovered in the Canadian measure. In addition to the varieties of color and specific gravity, together with the freedom from sulphur which characterizes the Pennsylvania petroleums and indicates the process of filtering, it is also extremely doubtful whether the measures of the Devonian age and particularly those in which the Pennsylvania petroleums are deposited, ever contained any life which could have given rise to the petroleum. It is generally conceded that the great volume of the oil which is found in the Trenton and Clinton limestones is due to chemical action upon the organic life of that period. The experience which has been the result of many years of drilling in Pennsylvania has failed to discover any evidence of organic life in the period in which the

Pennsylvania measures were deposited that even suggest a sufficient source for the great bodies of petroleum which have already been brought to the surface in that region."

In a communication received from Mr. MacGonigle to-day he calls attention to the fact that a line drawn from Brady's Bend to Waynesborough, Pa., will show the eastern limit of profitable oil pools in that region. East of that line, however, some of the most prolific gas pools of Pennsylvania have been developed, notably, Murrysville, Grapeville, Latrobe, etc. This would at least suggest a side light in favor of the theory above mentioned, showing that as the area approached the line of greatest upheaval and consequently greatest temperature, the volatile oil (gas) was, without condensation, retained in its condition as it came up from Silurian horizons.

I believe that this theory of Mr. MacGonigle is more probable than any that has been advanced as to the present condition of oil in Pennsylvania. It does not seem, however, necessary to introduce the idea of any redistillation whatever from the fact that if sufficient cracks existed in the cover over the Silurian limestones, the oils would leak through the shales to their present position without the application of any heat, and by experimental work it may easily be demonstrated that if we saturate a limestone such as the Trenton limestone with the oils characteristic of that rock and exert slight pressure upon it, so that it may flow upward through finely divided clay, it is easy to change it in its color to oils similar in appearance to the Pennsylvania oils, the oil which first filters through being lightest in color and the following oils growing darker. Further, if we examine oils in the new fields of Tennessee and Kentucky, we find as we go lower that oils which were light in color at the surface are dark in color when we go through the shales and find them in the lower limestones. In fact it is possible to watch the process of filtration from dark oils similar to the Ohio sulphur-bearing oils to the lighter oils of Pennsylvania found nearer the surface. The means by which the sulphur has been taken from the Ohio oil is far more difficult to explain, although the ease by which sulphur compounds and unsaturated compounds can be removed from petroleum by the use of aluminum chloride points to the chloride of some metal as a means by which this may have been accomplished.